

CLAIMS

What is claimed is:

1. A solid-state device having a thin-film piezoelectric material forming a
5 plurality of piezoelectric elements, a first set of the plurality of piezoelectric elements
generating a force, and a second set of the plurality of piezoelectric elements generating
an electrical signal in proportion to both the force and an acceleration of the solid-state
device while rejecting spurious noise.

2. A solid-state acceleration sensor device, comprising:
10 a first set of piezoelectric elements;
a second set of piezoelectric elements;
wherein the first set of piezoelectric elements including a piezoelectric
material and being actuated by an electrical signal, wherein when the electrical signal is
applied on the piezoelectric material, the second set of piezoelectric elements senses the
15 acceleration of the solid-state acceleration sensor device.

3. The solid-state acceleration sensor device of claim 2, wherein the first
and second sets of piezoelectric elements are configured on a thin-film piezoelectric
material.

4. The solid-state acceleration sensor device of claim 2, further
20 comprising a third set of piezoelectric elements that sense a force generated by the first
set of the piezoelectric elements.

5. The solid-state acceleration sensor device of claim 4, wherein a signal sensed by at least one set of the second and third sets of piezoelectric elements is fed back to the first set of piezoelectric elements.

6. The solid-state acceleration sensor device of claim 2, wherein the
5 electrical signal applied on the first set of piezoelectric elements is variable to modify a mechanical resonant frequency of the solid-state acceleration sensor device.

7. The solid-state acceleration sensor device of claim 2, wherein the piezoelectric material of the first set of the piezoelectric elements includes conductive electrodes placed on approximately opposite sides such that application of the electrical
10 signal to the conductive electrodes causes a longitudinal variation of the piezoelectric material.

8. The solid-state acceleration sensor device of claim 2, wherein the piezoelectric material is a thin-film piezoelectric material with a thickness of less than 10 microns and includes conductive electrodes placed on approximately opposite sides such
15 that application of the electrical signal to the conductive electrodes causes a longitudinal variation of the thin-film piezoelectric material.

9. The solid-state acceleration sensor device of claim 2, wherein the piezoelectric material is a thin-film piezoelectric material comprising a family of Lead-Zirconate-Titanate (PZT) compounds.

20 10. The solid-state acceleration sensor device of claim 2, wherein the solid-state device includes a semi-rigid member fixed along a first edge to a proof mass and fixed along a second edge to an outer base.

11. The solid-state acceleration sensor device of claim 10, wherein the semi-rigid support comprises a tuning fork.

12. The solid-state acceleration sensor device of claim 10, wherein the semi-rigid support comprises a vibrating cup.

5 13. The solid-state acceleration sensor device of claim 10, wherein the semi-rigid support comprises a comb structure.

14. The solid-state acceleration sensor device of claim 10, wherein the semi-rigid support comprises an annular ring.

15. A method of sensing an acceleration of a solid-state device formed by a
10 plurality of thin-film piezoelectric elements having a first set of piezoelectric elements, a second set of piezoelectric elements, and a third set of piezoelectric elements, comprising the steps of:

actuating the first set of piezoelectric elements by a first electrical signal;

and

15 sensing acceleration by the second and third sets of piezoelectric elements while rejecting spurious noise.

16. The method of claim 15, further comprising the steps of generating a second electrical signal by the second set of piezoelectric elements proportional to a mechanical force along a first direction, and generating a third electrical signal by the
20 third piezoelectric elements proportional to the mechanical force along a second direction, wherein the second direction is orthogonal to the first direction, and wherein

phase of the third electrical signal shifts relative to the second electrical signal in response to acceleration of the solid-state device along said second direction.

17. The method of claim 15, further comprising the steps of connecting the second and third electrical signals to a phase-shift detection circuit, and generating an
5 electrical output signal in proportion to a shift of the phase.

18. An acceleration sensor, comprising:
a proof mass;
a first piezoelectric element for generating a force on the proof mass along
a first direction by a first electrical signal;
10 a second piezoelectric element for generating a second electrical signal in proportion to the force on the proof mass along the first direction;
a third piezoelectric element for generating a third electrical signal in proportion to the force on the proof mass along a second direction; and
an electrical circuit connected to the first piezoelectric element for
15 applying the first electrical signal.

19. The acceleration sensor of claim 18, further comprising a phase shift detection circuit that generates an electric output signal in proportion to a phase shift between the second and third electrical signals.

20. The acceleration sensor of claim 18, further comprising a feedback circuit
20 for feeding back a signal sensed by at least one set of the second and third sets of the piezoelectric elements.

21. A method of sensing an acceleration of a solid-state device formed by a plurality of thin-film piezoelectric elements having a first set of piezoelectric elements and a second set of piezoelectric elements, comprising the steps of:

actuating the first set of piezoelectric elements by a first electrical signal;

5 sensing vibration of the solid-state device by the second set of piezoelectric elements; and

feeding back a portion of a sensed signal generated by the second set of piezoelectric elements to the first set of piezoelectric elements so as to actuate the first set of piezoelectric elements at a resonant frequency of the solid-state device.

10 22. The method of claim 21, further comprising a step of measuring frequency of the first electrical signal as a measure of acceleration of the solid-state device.

23. An acceleration sensor, comprising:

a proof mass;

15 a first plurality of piezoelectric elements for generating a force on the proof mass along a first direction by a first electrical signal;

a second plurality of piezoelectric elements for generating a second electrical signal in proportion to the force on the proof mass along the first direction; and

an electrical circuit connected to the first plurality of piezoelectric elements for applying the first electrical signal.

20 24. The acceleration sensor of claim 23, further comprising a feedback circuit for feeding back a portion of the second electrical signal to the first plurality of piezoelectric elements.

25. The acceleration sensor of claim 23, wherein the first and second plurality of piezoelectric elements are made of a thin-film piezoelectric material with a thickness of less than 10 microns and conductive electrodes placed on approximately opposite sides of the piezoelectric material such that application of an electrical signal to the conductive
5 electrodes causes a longitudinal variation of the thin-film piezoelectric material.